

Indelible footprint



The Anthropocene: A New Epoch of Geological Time?

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That the magnitude of human impacts on the environment is comparable to that of the great forces of nature will come as no surprise to most geoscientists. A special issue of the *Philosophical Transactions of the Royal Society* argues that the current period of planetary-scale human influence should be recognized as a separate geological epoch — the Anthropocene. Indeed, if humanity's imprint on the environment over the past two centuries is so mighty that it will be recorded in the geological archives forever, it seems logical to accept that this period of human influence is a new chapter in the geological history of our planet.

The history of the Anthropocene as an idea is explored in the first chapter. Nobel Prize winner Paul Crutzen is typically attributed with coining the term Anthropocene. But the concept can be traced back as far as the mid-nineteenth century, when the Italian geologist and Catholic priest Antonio Stoppani suggested that the Earth, through humanity's impact, was entering a new geological period, which he termed the Anthropozoic era. About half a century later, a Russian geochemist, Vladimir Vernadsky, developed the concept of the biosphere, casting it as a geological envelope around the planet's surface, with geochemical properties imprinted by life. He further hypothesized that humans (or, more precisely, scientific thought) would become a large-scale geological force, transforming the biosphere into the noosphere — an anthropogenically transformed Earth.

The history of human transformation of the terrestrial biosphere, and the irreversibility of these changes, is also explored. Erle Ellis describes how humans

started to influence land cover significantly some 10,000 years ago, when the development of agricultural systems led to a sustained growth in the human population. He points out that if massive amounts of land use were a marker of Anthropocene onset, the period would have begun before the year 1800 by which time many regions, including Europe, were already deforested. During the past two centuries, considerable use of fossil energy has led to much larger, industrial-scale changes in land cover, and so far about two-thirds of the terrestrial biosphere has been transformed by human activity. As Ellis points out, it seems almost certain that the scale of this transformation will persist in the geological archive.

The potential influence of past land use on climate is also briefly discussed. Palaeoclimatologist William Ruddiman introduced a proposal for an 'early Anthropocene' in 2003. He suggested that widespread deforestation and agricultural development began about 8,000 years ago, and led to an increase in the concentration of atmospheric greenhouse gases and the prevention of the next ice age. However, evidence for large-scale land-use change millennia ago is very fragile, and the idea has largely been rejected by the geological community. Today the year 1800, the approximate onset of the Industrial Revolution, is generally regarded as the start of the Anthropocene.

All geological epochs come to an end sooner or later. How long man's imprint on the environment will be evident is discussed in a chapter on anthropogenic modification of the oceans. It is suggested that even if anthropogenic carbon dioxide emissions were stopped today, a considerable fraction of the carbon released would persist in the atmosphere for many thousands of years, causing long-term acidification of the oceans and lasting global warming. On these timescales land ice could start to disappear, and the Greenland and West Antarctic ice sheets could melt away, causing pronounced sea-level rise. Indeed, evidence for smaller ice sheets in warm climates is clearly visible in geological records.

Another chapter examines the extent to which the geological past can inform us about the future. Warm geological periods between 100 and 2.5 million years ago are analysed, including the climate of the Late Cretaceous, a warm period around 70 million years ago; the Palaeocene–Eocene

Thermal Maximum, a period of abrupt warming about 55.5 million years ago; and the more recent Miocene and mid-Pliocene warm intervals. Despite an extensive search, no satisfactory analogue to the Anthropocene emerges. However, past warm intervals provide a unique opportunity to understand processes that operate during warm, high-carbon-dioxide climates. This information is invaluable in the evaluation of climate models used for future projections.

This Anthropocene-themed issue could, however, be criticized for omitting important issues. Although the geological history of the Earth is comprehensively considered, including an excellent summary of Anthropocene stratigraphy, an in-depth analysis of societal feedbacks to changes in the environment is missing. Possible developments in the Law of the Sea, which might be triggered by formal recognition the Anthropocene, and societal responses are discussed. But many other aspects, for example the overexploitation of fish resources and human impacts on the nitrogen and phosphorus cycles, are left untouched. And an image of Jakarta's skyscrapers on the issue cover is almost the only reminder of the powerful urbanization process. Furthermore, although genetic engineering of crops may have a profound effect on the biosphere, this emerging Anthropocene issue is not discussed in depth. As such, this collection of articles could be viewed as an introduction to the topic, rather than a well-balanced overview.

Without doubt, humans have already left their imprint on the geological record. Even millions of years from now a signal of pronounced warming and ocean acidification could be visible in marine sediments. Formal recognition of the Anthropocene, as proposed in this themed collection, would not only draw attention to the scale of human impacts on the planet, but would also stress our responsibility for the planet's future. As Vernadsky wrote almost seventy years ago on the emergence of the noosphere, "The future is in our hands. We will not let it go." □

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